Chapter 1
Introduction

1-1. Overview

a. As of November 1991, 35 percent of approximately 590,000 bridges in the United States were considered structurally deficient or functionally obsolete (Bagdasarian 1994). Many bridges have become deficient due to aging and heavier than expected service loads. In particular, some highway and railroad bridges ranging from 50 to more than 100 years old are still performing their intended functions in spite of excessive use (Scalzi 1988). The recent collapse or near-collapse of some bridges has resulted in the development of extensive inspection programs and engineering assessment methods to ensure that highway bridges are safe for public use.

b. Highway bridges are subjected to a wide range of vehicular loads. As vehicles cross, the live loads produce changing stresses which cause a wide range of strain or deformation in the members. The impact of a vehicle also contributes to the changing stresses. The relatively large range of repeated elastic strain or deformation places greater demands on the material properties of critical members and increases the probability of damage. In addition, bridges are relatively unprotected from the environment. Bridge members are exposed to water, debris, and contaminants such as deicing salts, and they must resist freeze/thaw damage and accommodate significant thermal movement.

c. Bridge deterioration typically occurs at specific locations related to deck drainage, debris accumulation, and exposure. Cracks can initiate at stress concentrations caused by certain framing details and fabrication defects. To evaluate the degree to which a deficiency effects safety often requires an appraisal of that specific deficiency's significance on the structural stability of the bridge. Locating the fracture critical members of the bridge, as well as assessing the criticality of deficiencies in the fracture critical members (FCMs), is necessary to determine if the bridge should remain open. An effective inspection plan must contain information helpful in locating problems on members with potentially high-risk modes of failure. Unless the inspector understands where to look and what to look for when inspecting bridges, the inspection activity will be ineffective. Cracks frequently start at stress concentrations and out-of-place stresses due to connections of transverse members. Additional information on structural inspection can be found in Chapter 2 of the AASHTO (1983) Manual for Maintenance Inspection of Bridges, and Chapter 18 of the FHWA (1991) Bridge Inspector's Training Manual 90.

1-2. Organization

This report summarizes the procedures for identification, inspection, and evaluation of FCMs of USACE in-service bridges on public roads. In Chapter 2, two bridges that cross the Chesapeake Bay to the Delaware River canal, Summit Inland Waterway Bridge and St. George's Highway Bridge, are analyzed using the finite element method to demonstrate a procedure of identifying FCMs. In Chapter 3, the structural degradation process due to fracture and fatigue is presented to provide background for critical assessment and inspection planning. A review of state-of-the-art techniques in structural damage monitoring and structural integrity assessment methodology is presented in Appendix B. This review summarizes information pertaining to new methodology and technology available for more effective inspection and evaluation of bridges. This report is not intended as a stand-alone technical resource on fracture critical members. However, several references are included to provide the reader with additional information. Information provided in this report and other referenced documents is in a mixture of SI metric units and inch kip units. A more consistent set of equations will be developed in a future Engineer Manual.